Message

From:	Shapiro, Mike [/O=EXCHANGELABS/OU=EXCHANGE ADMINISTRATIVE GROUP (FYDIBOHF23SPDLT)/CN=RECIPIENTS/CN=2C70AF880BA747B5A8B6BAA45A040125-MSHAPIRO]
Sent:	3/31/2016 12:15:05 PM
To:	Lousberg, Macara [Lousberg.Macara@epa.gov]; Evalenko, Sandy [Evalenko.Sandy@epa.gov]
CC:	Gude, Karen [Gude.Karen@epa.gov]
Subject:	RE: NASA Requests for Meeting on Office of Water Pending Actions

I have not responded yet. But I did send an email to Crystal Penman asking her to set up a meeting with the NASA folks, just forgot to copy you. Since Crystal is out this week I don't think she followed up, but you may want to check with Damara to see if she has done anything. As I indicated, I don't have to be part of the meeting if I'm not needed for protocol reasons.

Mike

Michael Shapiro
Deputy Assistant Administrator, Office of Water
US EPA, 4101M
1200 Pennsylvania Ave., NW
Washington, DC 20460
202-564-5700

From: Lousberg, Macara
Sent: Thursday, March 31, 2016 7:58 AM
To: Shapiro, Mike <Shapiro.Mike@epa.gov>; Evalenko, Sandy <Evalenko.Sandy@epa.gov>
Cc: Gude, Karen <Gude.Karen@epa.gov>
Subject: RE: NASA Requests for Meeting on Office of Water Pending Actions

Sure. Have you responded to Mr. McNeill or should I send him a note?

From: Shapiro, Mike
Sent: Wednesday, March 30, 2016 8:56 PM
To: Evalenko, Sandy <Evalenko.Sandy@epa.gov>; Lousberg, Macara <Lousberg.Macara@epa.gov>
Cc: Gude, Karen <Gude.Karen@epa.gov>
Subject: RE: NASA Requests for Meeting on Office of Water Pending Actions

Thanks, based on your responses I think a meeting with the NASA folks makes sense. I don't really know how their hierarchy works, but I am happy to participate if that is appropriate. We should certainly have reps from OST and OGWDW. Macara, could you work on setting something up? Thanks.

Mike

Michael Shapiro
Deputy Assistant Administrator, Office of Water
US EPA, 4101M
1200 Pennsylvania Ave., NW
Washington, DC 20460
202-564-5700

From: Evalenko, Sandy
Sent: Wednesday, March 30, 2016 6:42 PM
To: Lousberg, Macara <Lousberg.Macara@epa.gov>

Cc: Shapiro, Mike <Shapiro.Mike@epa.gov>; Gude, Karen <Gude.Karen@epa.gov>
Subject: Re: NASA Requests for Meeting on Office of Water Pending Actions

Sorry for a late response. Macara is correct.

1. Conductivity criteria or most independent scientific documents are not typically reviewed by OMB under the EO. The implementation guidance for the methyl-mercury criteria is the only criteria document with an interagency review since I've been in OW.

2. OMB determined the UCMR4 NPRM and the lead safe free act NPRM to be non-significant. Most likely Ex. 5 Deliberative Process (DP)
Ex. 5 Deliberative Process (DP)
Is NASA interested in getting data on a chemical or pollutant or something?
For the Lead Safe Free Act rule, the program is Ex. 5 Deliberative Process (DP)
Ex. 5 Deliberative Process (DP)

3. I think that Ex. 5 Deliberative Process (DP)
Ex. 5 Deliberative Process (DP)

4. NPDWR Perchlorate is significant. Our next big NPDWR is the long term lead and copper revisions rule. Both will have an interagency review.

I don't know what the intersection with NASA for our actions. It might be helpful to know what their interests or concerns are wrt our regs. Do you know who in ORD talked with NASA? I could ask Bob Fegley on ORD about their experience and discussions with NASA.

Let me know how I can assist.
Sandy

Sent from my iPhone

On Mar 23, 2016, at 8:48 AM, Lousberg, Macara <Lousberg.Macara@epa.gov> wrote:

> HI Mike. I looked these actions up in the Action Tracker report and Mr. McNeill is correct in most cases.
>
> Water quality criteria for specific chemicals: most show that we are proposing for them to Ex. 5 Deliberative Process (DP)
>
> Ex. 5 Deliberative Process (DP)
>
> Perchlorate proposal – significance request hasn't been submitted yet so we don't know. Hard to imagine OMB would say it's non-significant though.
>
> In Sandy's absence, I'm cc'ing Karen Gude in case she knows something more/different from what I outlined above.

From: Shapiro, Mike
Sent: Tuesday, March 22, 2016 10:50 PM
To: Lousberg, Macara <Lousberg.Macara@epa.gov>
Cc: Evalenko, Sandy <Evalenko.Sandy@epa.gov>
Subject: Fwd: NASA Requests for Meeting on Office of Water Pending Actions

What do you think of this note? Don't most of these actions go through interagency review?

Mike

Sent from my iPhone

Begin forwarded message:

> **From:** "Mcneill, Mike A (HQ-LD020)" <mike.a.mcneill@nasa.gov>
> **Date:** March 22, 2016 at 4:30:06 PM EDT
> **To:** "shapiro.mike@epa.gov" <shapiro.mike@epa.gov>
> **Subject: NASA Requests for Meeting on Office of Water Pending Actions**
>
> Dear Dr. Shapiro,
>
> Please allow me to introduce myself, I am the Deputy Director of NASA's Environmental Management Division (EMD). James Leatherwood, the EMD Director, and I request the opportunity to discuss with you a group of pending Office of Water actions. These actions, such as water quality criteria for specific chemicals, the UCMR4 proposed rule, the Ground Water Rule review, implementing regulations of SDWA prohibitions on lead pipes and solder, and perchlorate, have the potential to impact on NASA and other Federal agencies. Currently, no established interagency dialogue or review process is available in these Office of Water pending actions. We welcome starting a dialogue on these and related actions.
>
> Based on the success of the EPA IRIS process's interagency review, NASA requests the Office of Water consider **Ex. 5 Deliberative Process (DP)** Ex. 5 Deliberative Process (DP) As with the IRIS process, many of the identified Office of Water actions result in science policy decisions on action levels and implementation of regulations that potentially impact federal agencies in mission execution. Comparable federal agency experience with specific IRIS decisionmaking found interagency review strengthened the process, especially information sharing and collegiality among the participating federal agencies. We welcome discussing the targeted use of interagency review to support sound science in the Office of Water's decision making and promote communication and information sharing among federal agencies.
>
> I request that we discuss this matter. I am including the contact information of my scheduler, Ms. Bridget Mackall (bridget.d.mackall@nasa.gov, 202/358-2030) and my contact information (mike.a.mcneill@nasa.gov, 202/359-1886) should you prefer to call me directly. The NASA team looks forward to working with you and your team.
>
> Respectfully,
> Mike A. McNeill
>
> ====================================
> Mike A. McNeill, P.E.
> Deputy Director
> Environmental Management Division

NASA Headquarters
Suite 2T89, Room 2T81
300 E Street SW
Washington, DC 20546-0001
(202) 358-1886 FAX (909) 380-8607
"Enabling environmentally sound mission success"

Message

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Sent:	3/28/2016 3:04:29 AM
To:	Crystal Penman [penman.crystal@epa.gov]
Subject:	FW: NASA Requests for Meeting on Office of Water Pending Actions

Crystal,

Please set up the requested meeting – see the incoming from Mike Mcneill below. Participants for OW should include Macara Lousberg, representatives from OGWDW and OST. Thanks.

Mike

Michael Shapiro
Deputy Assistant Administrator, Office of Water
US EPA, 4101M
1200 Pennsylvania Ave., NW
Washington, DC 20460
202-564-5700

From: Lousberg, Macara
Sent: Wednesday, March 23, 2016 8:48 AM
To: Shapiro, Mike <Shapiro.Mike@epa.gov>
Cc: Evalenko, Sandy <Evalenko.Sandy@epa.gov>; Gude, Karen <Gude.Karen@epa.gov>
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Respectfully,
Mike A. McNeill

=====================================
Mike A. McNeill, P.E.
Deputy Director
Environmental Management Division
NASA Headquarters
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300 E Street SW
Washington, DC 20546-0001
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"Enabling environmentally sound mission success"

Predicted Effect of Perchlorate on Thyroid Hormone Levels in the Pregnant & Lactating Mother, Fetus, and Breast- and Bottle-Fed Infant: Model Dose-Response Application

Paul M Schlosser

U.S. Environmental Protection Agency, ORD, NCEA-Washington

September 27, 2016

Background

- In 2012, as required by the Safe Drinking Water Act, EPA sought guidance from the Science Advisory Board on how best to consider and interpret life stage information, epidemiologic and biomonitoring data, physiologically-based pharmacokinetic (PBPK) analyses and the totality of perchlorate health information to derive an MCLG for perchlorate.
- In 2013, the SAB recommended that:

  "... EPA derive a perchlorate MCLG that addresses sensitive life stages through physiologically-based pharmacokinetic/pharmacodynamic (PBPK/PD) modeling based upon its mode of action rather than the default MCLG approach using the reference dose and specific chemical exposure parameters"

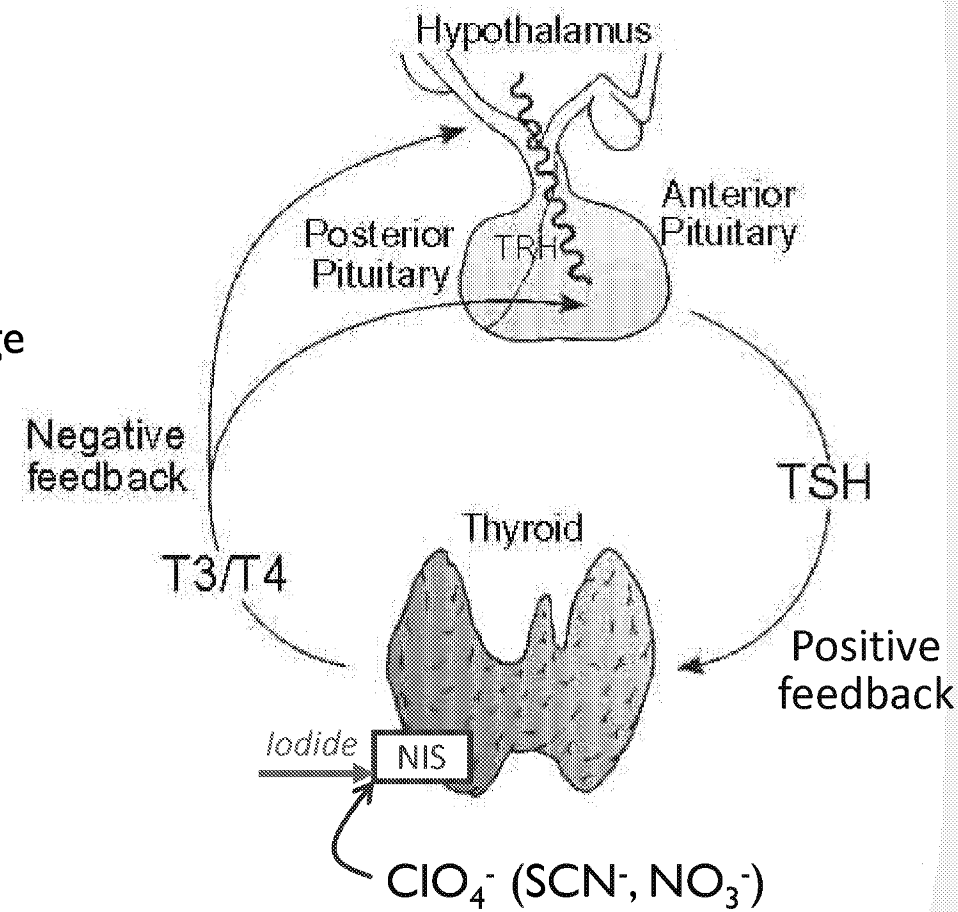
  "...the following MOA-based approach for using PBPK/PD modeling and additional clinical and toxicological data to inform the derivation of a health-protective MCLG recognizing that the sensitive populations for perchlorate exposure are the fetuses of hypothyroxinemic pregnant women, and infants exposed to perchlorate through either water-based formula preparations or the breast milk of lactating women"
- A team of scientists lead by Dr. Jeff Fisher, U.S. FDA, developed the Biologically Based Dose-Response (BBDR) model
  - Integrates PBPK models for perchlorate and iodide with BBDR models for thyroid hormones
  - Predicts effect of perchlorate on thyroid hormone levels in formula-fed and breast-fed infants, and lactating women, for postnatal days 7 to 90

Background II

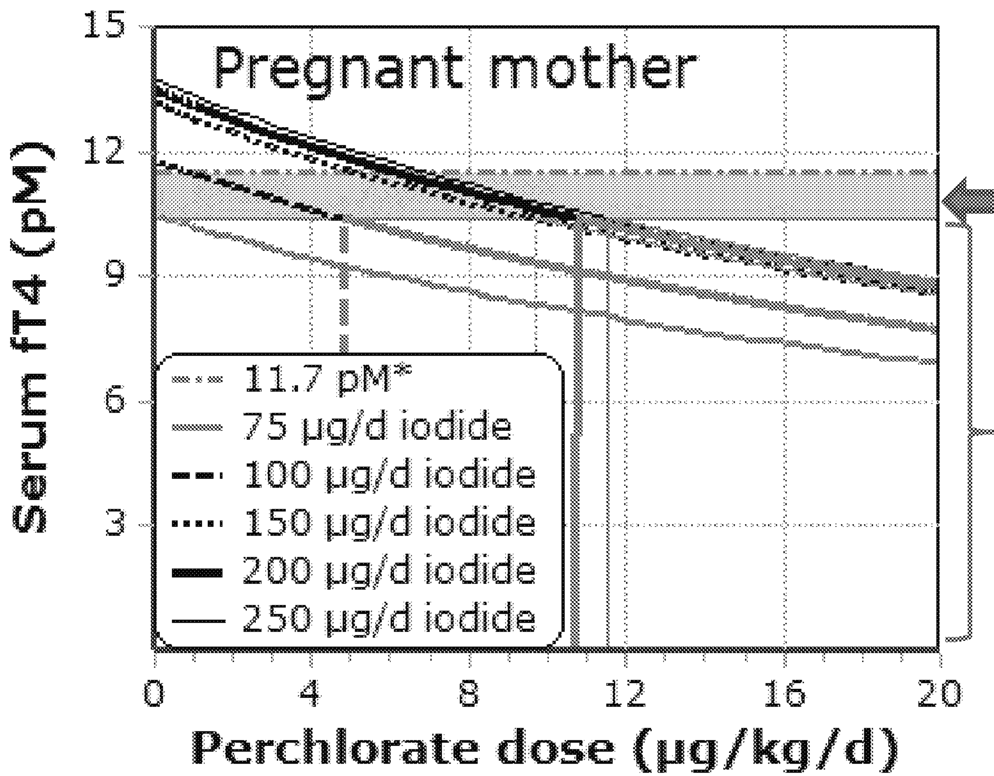
- June 2013: SAB Recommendations – EPA should:
  - Use hypothyroxinemia (hX) as immediate endpoint vs. Radio-Iodide Uptake (RAIU) Inhibition suggested by NAS in 2005
  - hX = moderate TH (T4 and T3) reduction, with thyroid stimulating hormone (TSH) in normal range
- Excluding TSH feedback makes the modeling less complex, but limits range for which it is valid
- Report includes statistical analyses to define range for hX
  - Range defined *relative to model-predicted fT4 levels for each life-stage*, given suggested iodine nutrition levels (i.e., euthyroid state)
  - This approach used to control for bias due to possible over- or under-prediction of the model vs. actual population mean TH levels
- Study populations providing data for model calibration, hence "controls" for perchlorate exposure, are assumed to have similar exposures to other goitrogens (SCN^-, NO_3^-) as populations of concern
  - Hence no specific correction for exposure to these other common goitrogens

General Picture

- **Idealized view:**
  - Small decreases in iodide ➔ small decreases in T3/T4
  - At some point T4 is low enough to be "hypothyroxinemia" (**hX**)
    - E,g., 10th %tile of reference range
    - But TSH changes are not yet significant
    - Can model this without describing hypothalamus & pituitary
    - Sensitive/initial adverse effect
  - If T4 falls low enough, **then** TSH feedback is triggered: ➔ hypothyroidism **(hO)**



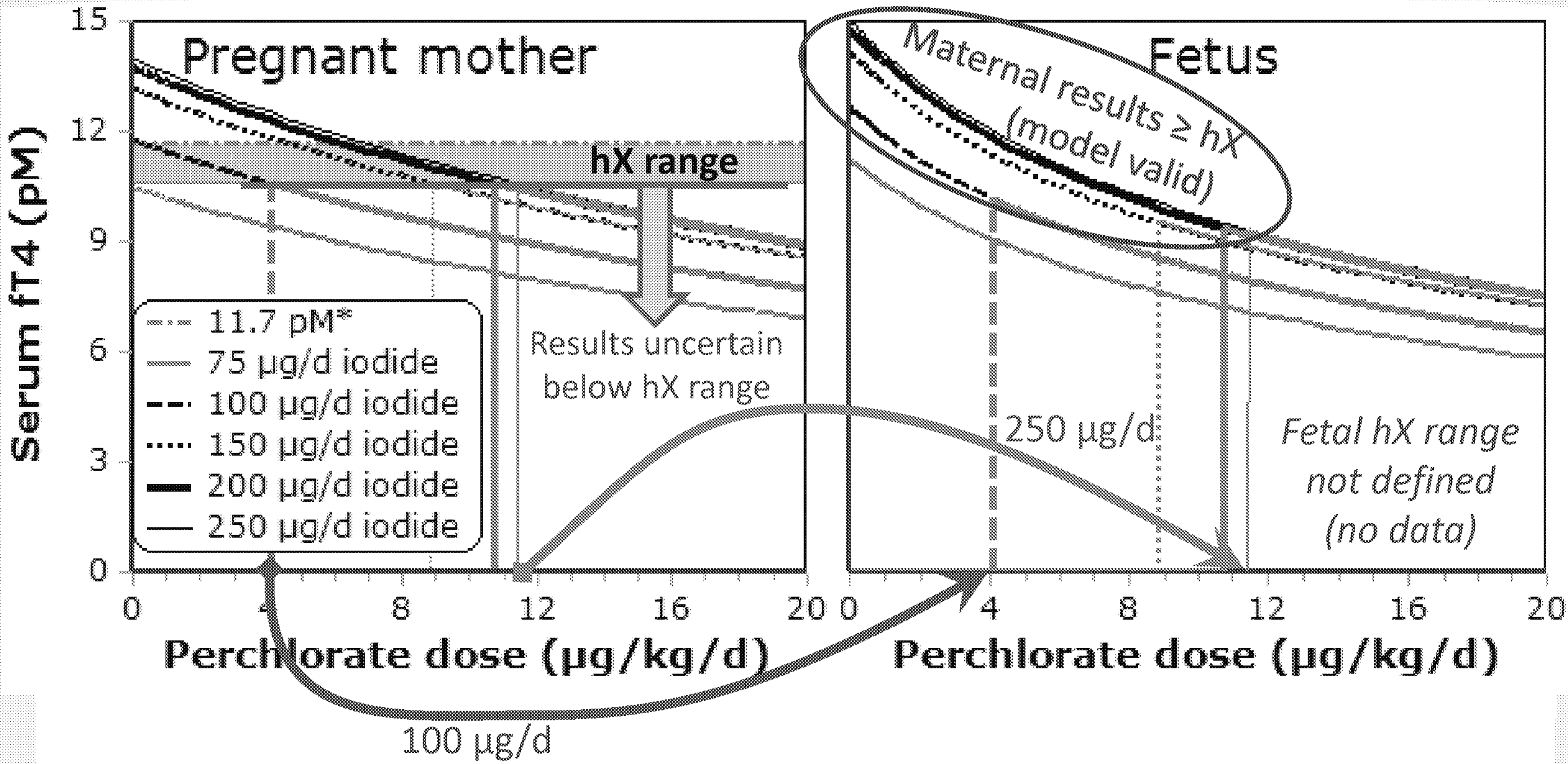
Pregnancy Dose-Response: 1st View



hypothyroxinemia range (extrapolated to BBDR model)

Hypothyroidism assumed, so model not valid

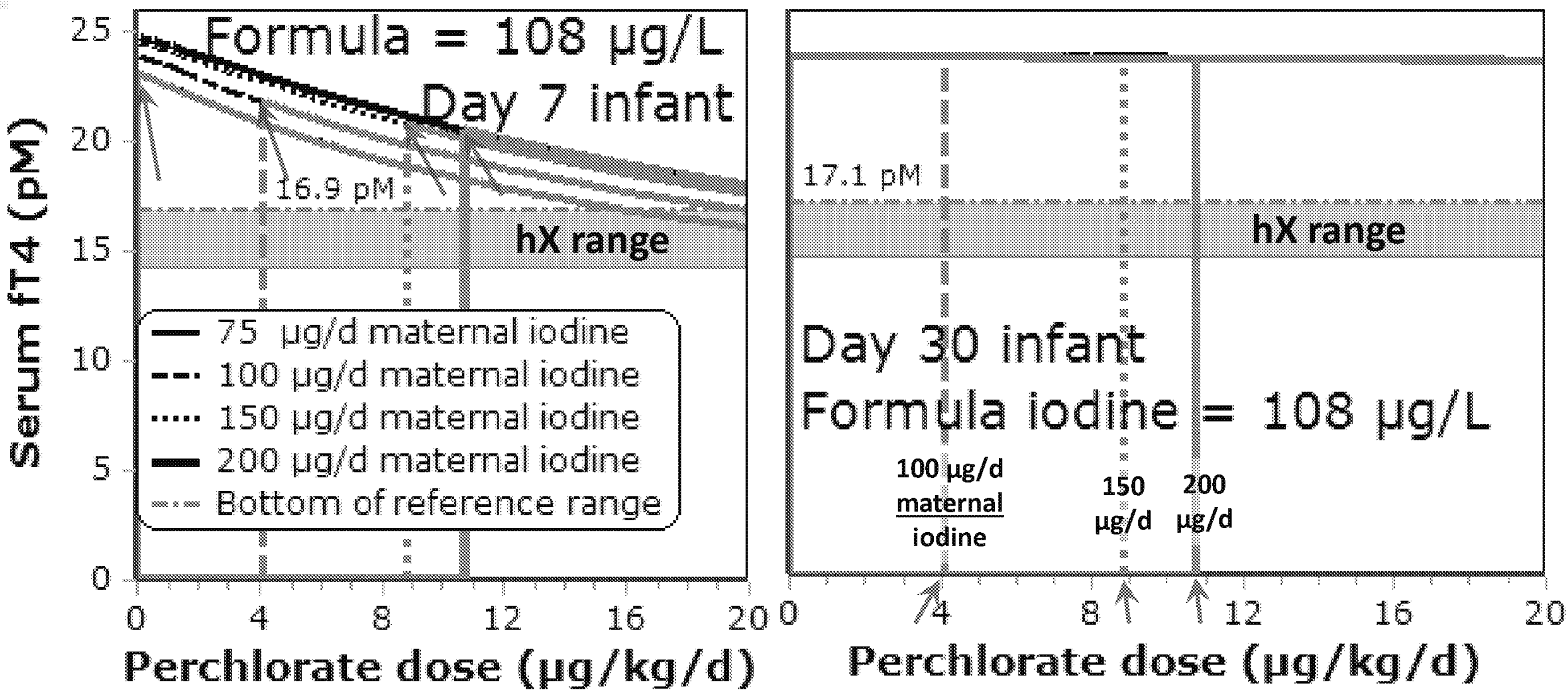
Pregnancy Dose-Response: 2nd View



Free T4 (fT4) levels as a function of perchlorate exposure and dietary iodine ingestion in the gestation-week 40 pregnant mother and fetus.

Bottle/formula-fed Infant: Day 7

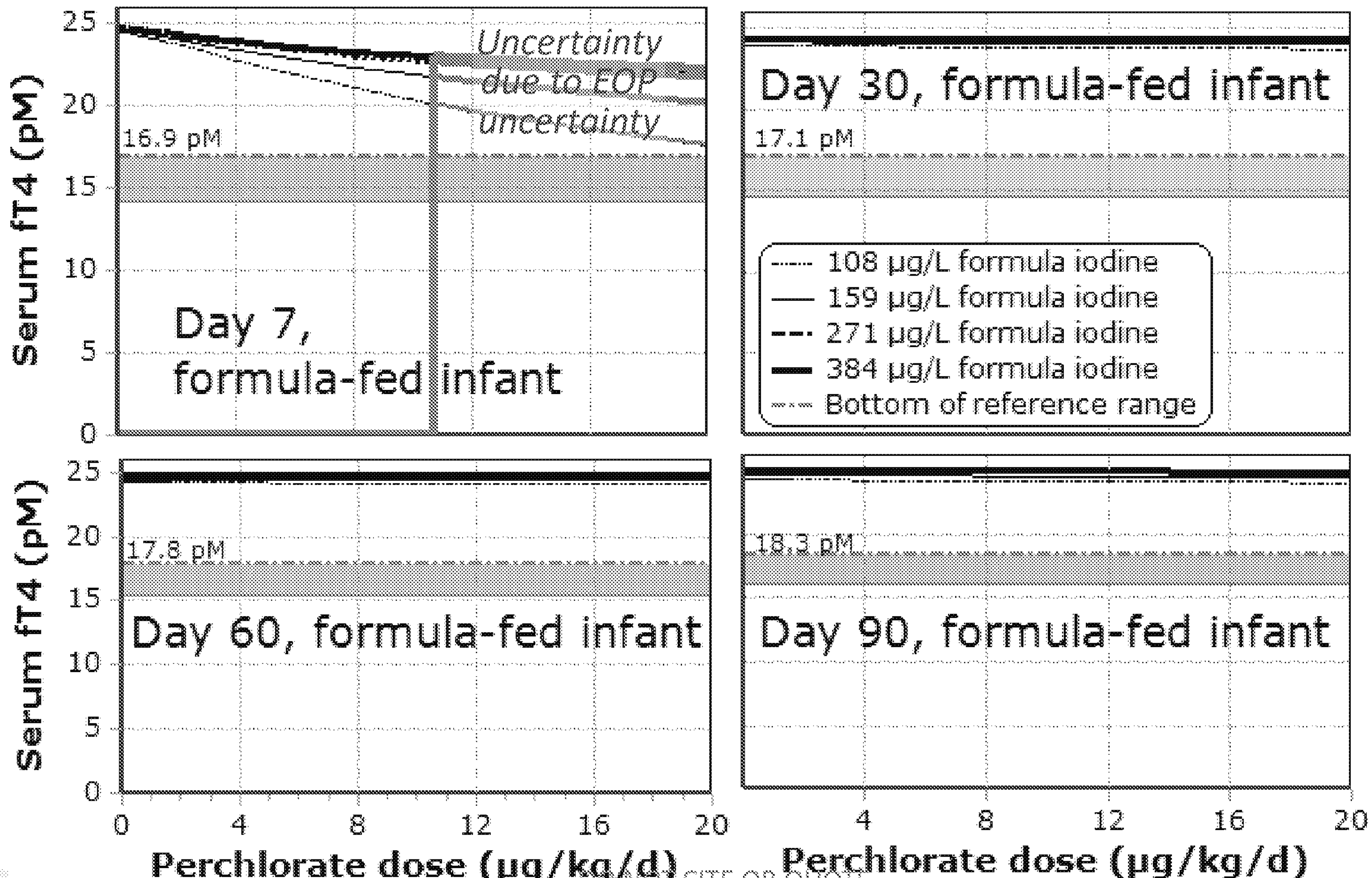
Iodide, TH, and perchlorate levels at birth predicted by pregnancy model.
Infinite possible combinations of exposure during vs. after birth!
108 µg/L = low formula iodine



Uncertainty above noted perchlorate levels due to uncertainty at end of pregnancy (EOP)

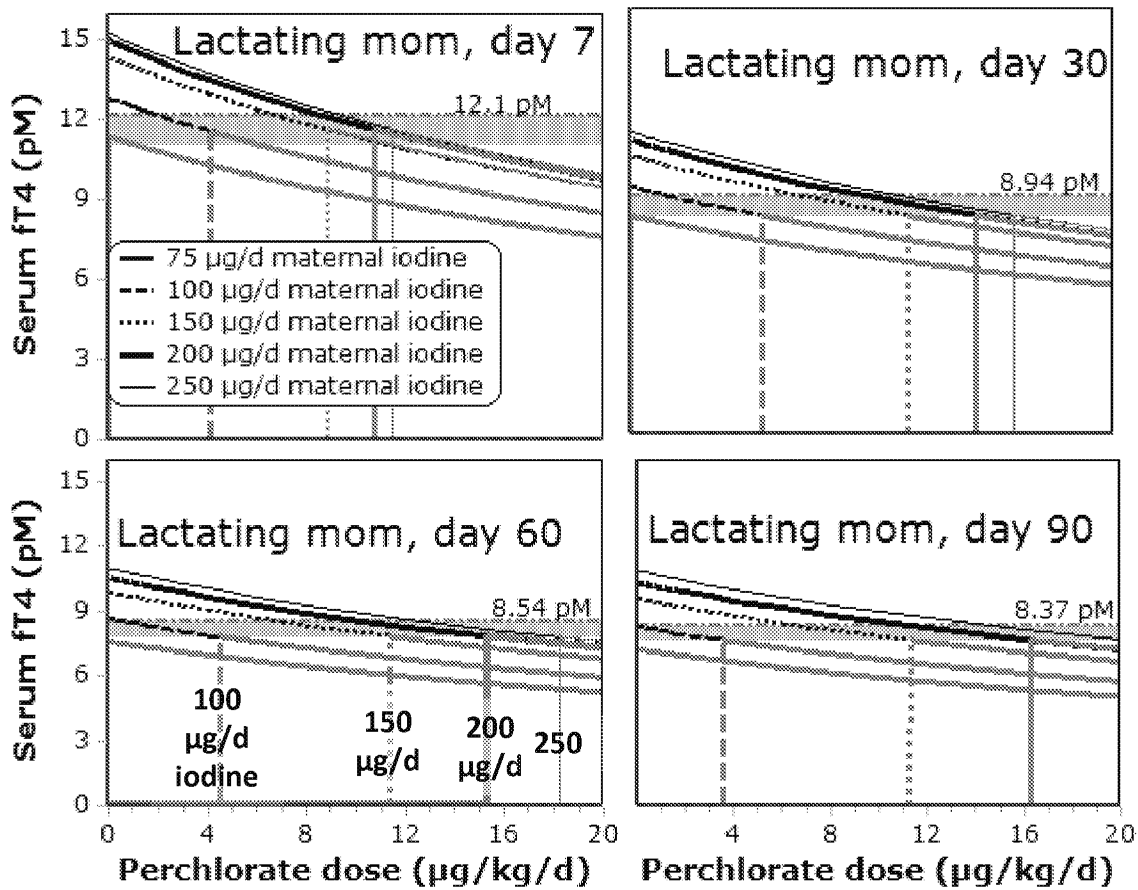
Bottle/formula-fed Infant: Days 7-90 200 μg/d iodine during pregnancy

Variation on day 7 due to varying formula iodine concentration
For days 30-90, infant's fT4 is ~ saturated for all formula iodine levels

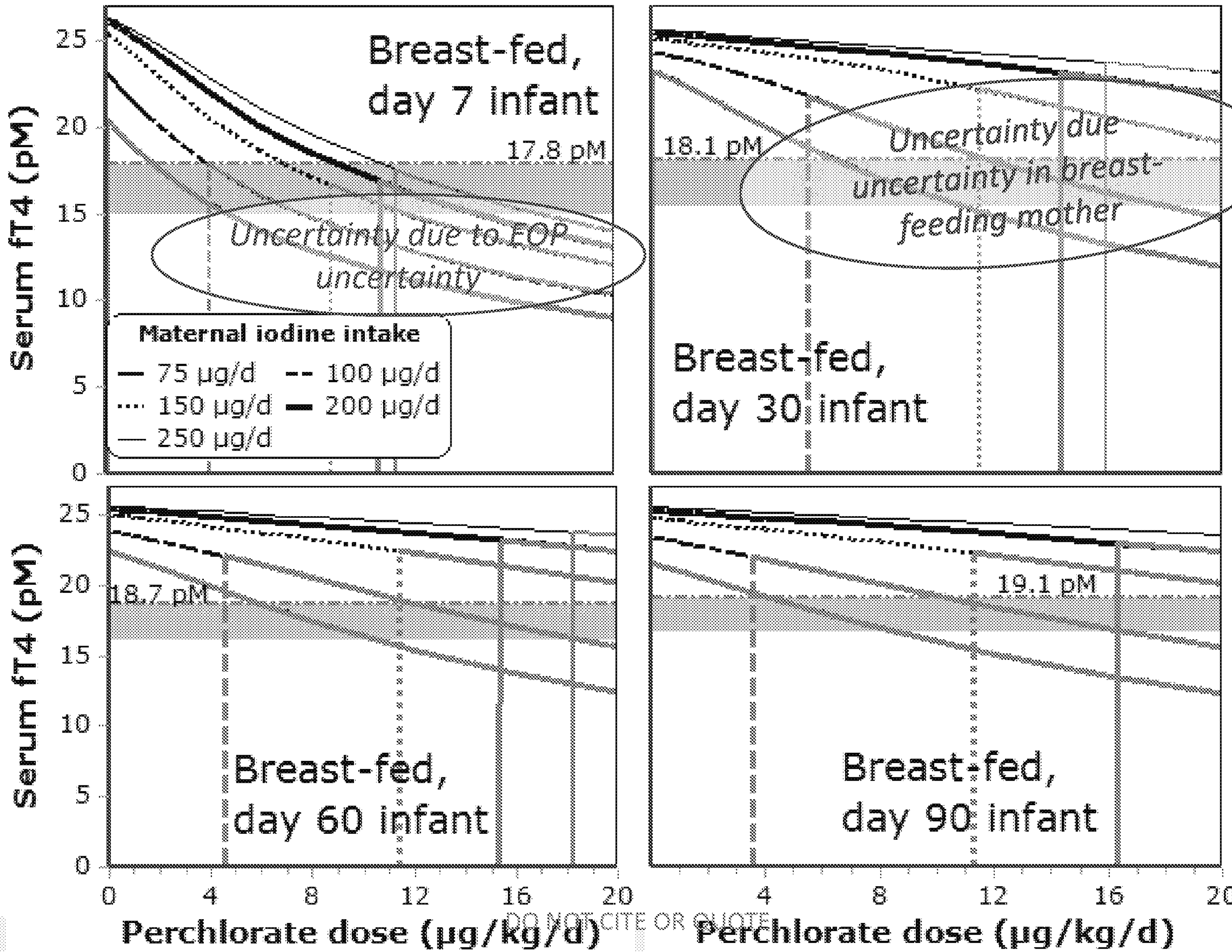


Breast-feeding mother: maternal nutrition & perchlorate exposure = pregnancy levels

Day 0 (birth) tissue levels from EOP predictions.
So Day 7 predictions assumed uncertain if EOP predictions uncertain!
For Days 30-90, uncertainty occurs when model < hX range.

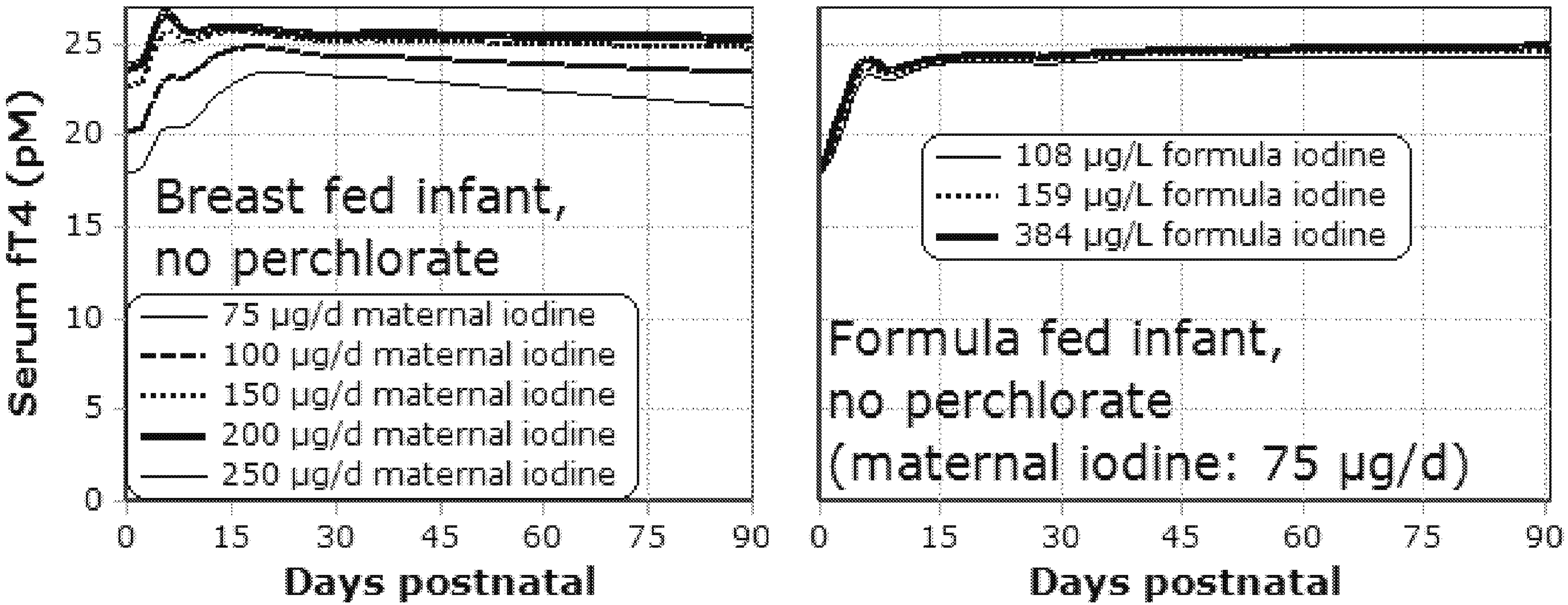


Breast-fed infant: maternal nutrition & perchlorate exposure = pregnancy levels



DO NOT CITE OR QUOTE

Breast- vs. formula-fed infant



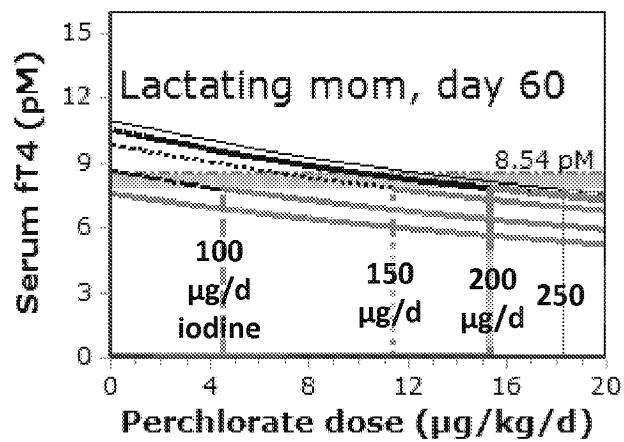
- **Low (measured) formula iodine are sufficient vs. higher perchlorate levels**
- **Breast fed infant is sensitive when maternal iodine nutrition < 150 µg/d**
- **But breast-feeding mother predicted to become hypothyroxinemic at perchlorate levels < those that would cause this effect in her infant**
- **Results suggest that avoiding hX in the mother should protect the infant**

Summary: Formula-/Breast-Fed Infant & Lactating Mom (Perchlorate ≤ 20 µg/kg/d)

- **Postnatal Day (PND) 7: infant & maternal TH levels primarily determined by maternal nutrition & perchlorate exposure <u>during pregnancy</u>**
  - **<u>Implication</u>: protecting the pregnant mother & fetus also protects the new-born infant (evaluated at 7 days)**

- **Formula-fed infant (30-90 days postnatal):**
  - **> 100 µg/L iodine levels found in infant formulas**
  - **Effectively saturate infant thyroid's need / capacity for TH production**
  - **Negligible effect of perchlorate up to 20 µg/kg/d (infant stays euthyroid)**

- **Lactating mother (PND 30-90):**
  - **Sensitive to iodine nutrition & perchlorate**
  - **Iodine demands of breast feeding ↑ sensitivity**



- **Breast-fed infant (PND 30-90):**
  - **Sensitive to iodine nutrition & perchlorate**
  - **<u>But less sensitive than the lactating mother</u>**
  - **Stays euthyroid when mother's TH fall into hX range**
  - **<u>Implication</u>: if the lactating mother is protected, the infant is also protected**

United States Environmental Protection Agency

Technical Fact Sheet – Perchlorate

April 2017

TECHNICAL FACT SHEET – PERCHLORATE

At a Glance

- Both naturally occurring and man-made anion.
- Contamination has been found at sites involved in the manufacture, maintenance, use and disposal of ammunition and rocket fuel.
- Highly soluble in water; migrates quickly from soil to groundwater.
- Primary pathways for human exposure include ingestion of contaminated food and drinking water.
- Affects thyroid gland by interfering with iodide uptake.
- EPA issued Interim Drinking Water Health Advisory.
- Various states have screening values or cleanup goals for perchlorate in drinking water or groundwater.
- Various detection methods available.
- Common treatment technologies include ion exchange, bioremediation and membrane technologies.

Introduction

This fact sheet, developed by the U.S. Environmental Protection Agency (EPA) Federal Facilities Restoration and Reuse Office (FFRRO), provides a summary of the contaminant perchlorate, including physical and chemical properties; environmental and health impacts; existing federal and state guidelines; detection and treatment methods; and additional sources of information. This fact sheet provides basic information on perchlorate to site managers and other field personnel who are addressing perchlorate contamination at cleanup sites or in drinking water supplies.

What is perchlorate?

- Perchlorate is a naturally occurring and man-made anion that consists of one chlorine atom bonded to four oxygen atoms (ClO_4^-). Manufactured forms of perchlorate include perchloric acid and salts such as ammonium perchlorate, sodium perchlorate and potassium perchlorate (EPA FFRRO 2005; ITRC 2005).
- Perchlorate is commonly used in solid rocket propellants, munitions, fireworks, airbag initiators for vehicles, matches and signal flares (EPA FFRRO 2005; ITRC 2005). It is also used in some electroplating operations (ATSDR 2008; ITRC 2005).
- Of the domestically produced perchlorate, 90 percent is manufactured for use in the defense and aerospace industries, primarily in the form of ammonium perchlorate (GAO 2005; ITRC 2005).
- Perchlorate may occur naturally, particularly in arid regions such as the southwestern United States (Rao and others 2007).
- Perchlorate is found as a natural impurity in nitrate salts from Chile, which are imported and used to produce nitrate fertilizers, explosives and other products (EPA FFRRO 2005; ITRC 2005).

What is perchlorate? (continued)

Exhibit 1: Physical and Chemical Properties of Perchlorate Compounds
(ATSDR 2008; EPA FFRRO 2005; ITRC 2005; NIOSH 2014)

Property	Ammonium Perchlorate	Sodium Perchlorate	Potassium Perchlorate	Perchloric Acid
Chemical Abstracts Service (CAS) numbers	7790-98-9	7601-89-0	7778-74-7	7601-90-3
Physical description (physical state at room temperature)	White orthorhombic crystal	White orthorhombic deliquescent crystal	Colorless orthorhombic crystal or white crystalline powder	Colorless, oily liquid
Molecular weight (g/mol)	117.49	122.44	138.55	100.47
Water solubility (g/L at 25°C)	200	2,100	15	Miscible in cold water
Melting / Boiling point* (°C)	Melting point: 130	Melting point: 471 to 482	Melting point: 400 to 525	Melting point: -112 Boiling point: 19
Vapor pressure at 25°C (mm Hg)	Very low	Very low	Very low	N/A
Specific gravity (g/cm^3)	1.95	2	2.52	1.77
Octanol-water partition coefficient (log K_{ow})	-5.84	-7.18	-7.18	-4.63

*Different melting point temperatures are identified in literature.
Abbreviations: g/mol – grams per mole; g/L – grams per liter; °C – degrees Celsius; mm Hg – millimeters of mercury; g/cm^3 – grams per cubic centimeter.

What are the environmental impacts of perchlorate?

- Perchlorate is highly soluble in water, and relatively stable and mobile in surface and subsurface aqueous systems. As a result, perchlorate plumes in groundwater can be extensive (ITRC 2005). For example, the perchlorate plume at a former safety flare manufacturing site (the Olin Flare Facility) in Morgan Hill, California, extends 10 miles (Cal/EPA 2016b).
- Because of their low vapor pressure, perchlorate compounds and the perchlorate anion do not volatilize from water or soil surfaces to air (ATSDR 2008; ITRC 2005).
- Perchlorate released directly to the atmosphere is expected to readily settle through wet or dry deposition (ATSDR 2008).
- High concentrations of perchlorate have been detected at current and Formerly Used Defense Sites historically involved in the manufacture, testing and disposal of ammunition and rocket fuel or at industrial sites where perchlorate is manufactured or used as a reagent during operations (ATSDR 2008; ITRC 2005).
- Types of military and defense-related facilities with known releases include missile ranges and missile and rocket manufacturing facilities. However, since site-specific documentation may not be available and based on historical uncertainties, it is generally difficult to identify specific military sites with known perchlorate releases (ITRC 2005).
- From 1997 to 2009, the Department of Defense reported perchlorate detections at 284 (almost 70 percent) of its installations sampled (GAO 2010).
- In addition, the past disposal of munitions in either burial pits or by open burning and open detonation may have resulted in releases to the environment. The amount of perchlorate released can vary depending on the length of time the disposal area was used and the types of munitions disposed of in the area (ITRC 2005).
- Nitrate is commonly found as a co-contaminant in water with perchlorate because ammonium nitrate is a main component in rocket fuel and explosives (DoD ESTCP 2013).
- Studies have shown perchlorate accumulates in some food crop leaves, tobacco plants and in broad-leaf plants (ATSDR 2008).
- Surveys conducted by the U.S. Food and Drug Administration have detected perchlorate in food crops and milk (Murray and others 2008).

What are the environmental impacts of perchlorate? (continued)

- As of October 2009, perchlorate had been detected at varying levels in drinking water, groundwater, surface water, soil or sediment at private and federal facilities in 45 states, three U.S. territories and Washington D.C. The maximum concentrations reported in any media ranged from less than 4 parts per billion (ppb) to 2.6 million ppb (GAO 2010).
- EPA reported perchlorate detections at 40 hazardous waste sites on the EPA National Priorities List as of June 2010 (GAO 2010).

What are the routes of exposure and the health effects of perchlorate?

- Primary pathways for human exposure to perchlorate are ingestion of contaminated food and drinking water (ATSDR 2008; EPA FFRRO 2005).
- After perchlorate is ingested, it quickly passes through the stomach and intestines and enters the bloodstream (ATSDR 2008).
- The thyroid gland is the primary target of perchlorate toxicity in humans. Thyroid hormones play an important role in regulating metabolism and are critical for normal growth and development in fetuses, infants and young children. Perchlorate can interfere with iodide uptake into the thyroid gland at high enough exposures, disrupting the functions of the thyroid and potentially leading to a reduction in the production of thyroid hormones (ATSDR 2008; Cal/EPA 2015; National Research Council 2005).
- Potassium perchlorate was historically used to treat hyperthyroidism because of its ability to inhibit thyroid iodide uptake (ATSDR 2008; National Research Council 2005).
- Studies conducted on rodents showed that perchlorate concentrations below that required to alter thyroid hormone equilibrium are unlikely to cause thyroid cancer in human beings (ATSDR 2008; EPA IRIS 2005).
- Short-term exposure to high doses of ammonium, sodium or potassium perchlorate may cause eye, skin and respiratory tract irritation, coughing, nausea, vomiting and diarrhea. Perchloric acid is corrosive to the eyes, skin and respiratory tract, and short-term exposure to high doses may cause sore throat, coughing, labored breathing, deep burns, loss of vision, abdominal pain, vomiting or diarrhea (NIOSH 2014).

Are there any federal and state guidelines and health standards for perchlorate?

- EPA assigned perchlorate a chronic oral reference dose (RfD) of 0.0007 milligrams per kilogram per day (mg/kg/day). The RfD is an estimate of a daily exposure level that is likely to be without non-cancer health effects over a lifetime (EPA IRIS 2005).
- The Agency for Toxic Substances and Disease Registry (ATSDR) has established a minimal risk level (MRL) of 0.0007 mg/kg/day for chronic-duration oral exposure (365 days or more) to perchlorate. An MRL is an estimate of the daily human exposure to a hazardous substance that is likely to be without appreciable risk of adverse non-cancer health effects over a specified duration of exposure (ATSDR 2008, 2016).
- In 2011, EPA determined that perchlorate meets the Safe Drinking Water Act criteria for regulation as a contaminant. EPA then worked with the FDA to develop a dose-response model to analyze the effects of perchlorate on thyroid hormone production. In 2017, EPA completed a peer review to evaluate EPA's draft dose-response model. A future peer review will evaluate EPA's draft approach for deriving a Maximum Contaminant Level Goal (MCLG) for perchlorate in drinking water (EPA 2017).
- In 2008, EPA established an Interim Drinking Water Health Advisory of 15 micrograms per liter (µg/L) for perchlorate. Exposure to this level for more than 30 days, but less than a year, is not expected to cause any adverse non-cancer effects. Health Advisories serve as informal guidance to assist managers of water systems; they are not legally enforceable standards (EPA 2008, 2012).
- EPA has calculated a tapwater screening level of 14 µg/L for perchlorate and perchlorate salts (EPA 2016b).
- EPA's Office of Land and Emergency Management recommends a preliminary remedial goal (PRG) of 15 µg/L at Superfund sites where there is an actual or potential drinking water exposure pathway, and where no applicable or relevant and appropriate requirements exist under federal or state laws (EPA 2009).

Are there any federal and state guidelines and health standards for perchlorate? (continued)

- California (6 µg/L) and Massachusetts (2 µg/L) have established enforceable standards for perchlorate in drinking water (Cal/EPA 2016c; Massachusetts DEP 2016).
- Various states have adopted screening values or cleanup goals for perchlorate in drinking water or groundwater, ranging from 0.8 to 71 µg/L:

State	Guideline (µg/L)	Source
Alabama	24.5	ADEM 2008
California	1 (public health goal)	Cal/EPA 2016a
Colorado	4.9	CDPHE 2016
Florida	4	FDEP 2005
Illinois	4.9	IL EPA 2016
Indiana	15	IDEM 2016
Kansas	11 (residential) 71 (non-residential)	KDHE 2015
Maine	0.8	MDEP 2016
Maryland	2.6	MDE 2008
Nebraska	6.4	NDEQ 2012
Nevada	18	NDEP 2015
New Mexico	25.6	NMED 2012
Pennsylvania	15	PADEP 2011
Texas	17	TCEQ 2016
Utah	14	UDEQ 2012
Vermont	2 (interim preventive action level); 4 (interim enforcement standard)	VTDEC 2015
Virginia	15	VDEQ 2014
West Virginia	11	WVDEP 2014
Wyoming	23.3	WDEQ 2016

- EPA has calculated soil screening levels of 55 milligrams per kilogram (mg/kg) for residential areas and 820 mg/kg for industrial areas for perchlorate and perchlorate salts (ammonium, potassium, sodium and lithium) (EPA 2016b).
- Various states have adopted screening values or cleanup goals for perchlorate in soil, ranging from 0.1 to 150 mg/kg for residential areas, and from 5 to 2,000 mg/kg for industrial areas.

What detection and site characterization methods are available for perchlorate?

- Drinking water, groundwater and surface water:
  - EPA Method 314.0 - Ion Chromatography (EPA 2016a)
  - EPA Method 314.1 Rev 1.0 - Inline Column Concentration/Matrix Elimination Ion Chromatography with Suppressed Conductivity Detection (EPA 2016a)
  - EPA Method 314.2 - Two-Dimensional Ion Chromatography with Suppressed Conductivity Detection (EPA 2016a)
  - EPA Method 331.0 Rev. 1.0 - Liquid Chromatography/Electrospray Ionization/Mass Spectrometry (EPA 2016a)
- Drinking water: EPA Method 332.0 - Ion Chromatography with Suppressed Conductivity and Electrospray Ionization Mass Spectrometry (EPA 2016a)
- Surface water, groundwater, wastewater, salt water and soil: EPA SW-846 Method 6850 - High Performance Liquid Chromatography/Electrospray Ionization/Mass Spectrometry (EPA 2016c)
- Surface water, groundwater, salt water and soil: EPA SW-846 Method 6860 - Ion Chromatography/ Electrospray Ionization/Mass Spectrometry (EPA 2016c)
- The presence of high amounts of other anions, such as chloride, sulfate or carbonate, may interfere with the analysis of perchlorate (EPA 1999).
- Researchers have developed methods to distinguish man-made and natural sources of perchlorate in water samples using chlorine and oxygen stable isotope ratio analysis (Bŏhlke and others 2005; ITRC 2005; Sturchio and others 2014).

What technologies are being used to treat perchlorate?

- **Ex Situ Treatment**
  - Ion exchange using perchlorate-selective or nitrate-specific resins is a proven method for removal of perchlorate from drinking water, groundwater, and surface water (ITRC 2008).
  - Ex situ bioremediation is being used to treat a large perchlorate plume in southern Nevada (NDEP 2011).

What technologies are being used to treat perchlorate? (continued)

- Membrane technologies including electrodialysis and reverse osmosis have been used to remove perchlorate from groundwater, surface water and wastewater; however, these all require subsequent disposal of the perchlorate removed (EPA FFRRO 2005; ITRC 2008).
- Although standard granular activated carbon (GAC) does not efficiently remove perchlorate, the adsorptive capacity of GAC may be increased through the addition of a surface-active coating to produce a modified or tailored GAC. Tailored GAC has proven to be effective for treating perchlorate in water; however, it produces a waste stream requiring management (Hou and others 2013; ITRC 2008).
- Laboratory-study results indicate that an electrically switched ion exchange system using a conductive carbon nanotube nanocomposite material could be used for the large-scale treatment of wastewater and drinking water. This approach would produce less secondary waste than conventional ion exchange processes (DoD SERDP 2011).
- A recent field study demonstrated the effective treatment of perchlorate-contaminated groundwater to below detection limits using a large-scale weak base anion resin ion exchange system. This system allows efficient and economical regeneration of the spent resin (DoD ESTCP 2012b).
- A fluidized bed biological reactor treatment train successfully treated low concentrations of perchlorate in groundwater to meet the California drinking water standards (6 µg/L) in a field study. The microbial process completely destroyed the perchlorate molecules, so no subsequent treatment or waste disposal was needed (DoD ESTCP 2009b).
- Laboratory study results indicate that ultraviolet laser reduction can be used to decompose low levels of perchlorate (below 100 µg/L) in water. This technology is currently undergoing laboratory testing and has not yet been commercialized or used in full-scale systems (ITRC 2008). One laboratory study found that ultraviolet light and sulfite are able to degrade perchlorate when used together, but not when used alone (Vellanki and others 2013).

In Situ Treatment

- Enhanced in situ bioremediation using ubiquitous perchlorate-reducing microbes can be an effective method for degrading perchlorate in groundwater and soil, at a lower cost than ex situ methods (DoD SERDP 2002; ITRC 2008; Stroo and Ward 2008).
- In situ bioremediation is being used to treat a large perchlorate plume in southern Nevada. Perchlorate-contaminated groundwater is extracted and amended with nutrients followed by re-injection into the subsurface (NDEP 2011).
- A laboratory study found that adding acetate or hydrogen as electron donors can increase perchlorate removal efficiency in groundwater (Wang and others 2013).
- Field study demonstration results indicate that a horizontal flow treatment well system can effectively deliver electron donor and promote the in situ biological reduction of perchlorate in groundwater (DoD ESTCP 2009c).
- A field study evaluated the use of gaseous electron donor injection technology for the anaerobic biodegradation of perchlorate in vadose zone soil. Results showed an average perchlorate destruction of more than 90 percent within the targeted 10-foot radius of influence within five months (DoD ESTCP 2009d).
- A field study evaluated the use of an emulsified oil biobarrier to enhance the in situ anaerobic biodegradation of perchlorate and chlorinated solvents in groundwater. Within 5 days of injection, perchlorate was degraded from an initial concentration range of 3,100 to 20,000 µg/L to below detection limits (less than 4 µg/L) in the injection and nearby monitoring wells (DoD SERDP 2008).
- A field study demonstrated that enhanced in situ bioremediation of perchlorate-impacted groundwater is effective using either an active or semi-passive approach. The active approach used on-going groundwater recirculation and delivery of an electron donor; perchlorate concentrations as high as 4,300 µg/L were reduced to less than 4 µg/L within 50 feet of the electron donor delivery/recharge well. The semi-passive approach involved periodic delivery of electron donor; perchlorate concentrations were reduced from levels over 800 µg/L to an average concentration of 3.4 µg/L (DoD ESTCP 2009a, 2012a).
- Laboratory and field studies have demonstrated the potential for using monitored natural attenuation to treat perchlorate in groundwater (DoD ESTCP 2010).

What technologies are being used to treat perchlorate? (continued)

- Several bench-scale tests have demonstrated the potential effectiveness of phytoremediation and constructed wetlands to treat perchlorate-contaminated media; limited field study demonstrations have been implemented (ITRC 2008). Recent laboratory study results indicate that the wetland plant, *Eichhornia crassipes*, may be an effective plant for constructing a wetland to remediate high levels of perchlorate in water based on its high tolerance and accumulation ability (He and others 2013).
- DoD's environmental research programs have funded many projects to research the remediation of perchlorate. For more information, see [HYPERLINK "https://www.serdp-estcp.org/Featured-Initiatives/Cleanup-Initiatives/Perchlorate"] and [HYPERLINK "https://www.serdp-estcp.org/Tools-and-Training/Environmental-Restoration/Perchlorate"].

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Additional information on perchlorate can be found at EPA's [HYPERLINK "http://www.cluin.org/perchlorate"].

Contact Information

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